

# Micromegas TPC

## Magnetic field cosmic ray tests

F. Bieser<sup>1</sup>, R. Cizeron<sup>2</sup>, P. Colas<sup>3</sup>, C. Coquelet<sup>3</sup>, E. Delagnes<sup>3</sup>, A. Giganon<sup>3</sup>, I. Giomataris<sup>3</sup>, G. Guilhem<sup>2</sup>, V. Lepeltier<sup>2</sup>, V. Puill<sup>2</sup>, Ph. Reboursgeard<sup>3</sup>, J.-P Robert<sup>3</sup>, M. Ronan<sup>1</sup>

1) LBNL Berkeley, 2) LAL Orsay, 3) DAPNIA Saclay

- Review of previous Micromegas studies
- Large area Micromegas TPC prototype chamber tested with Ar-Methane 10% (P10)
- Cosmic ray test setup fully operational
- Pilot run in magnetic fields (0.5, 1, 2T)

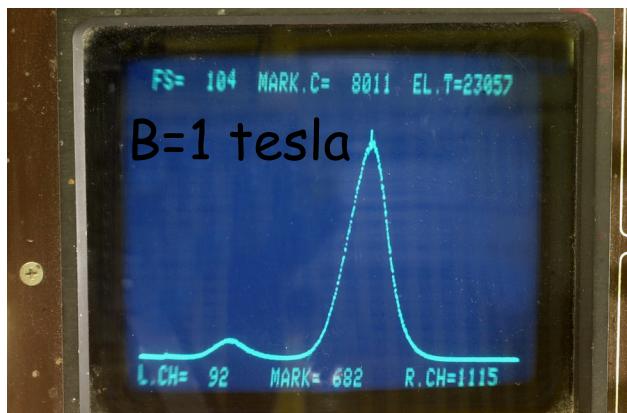
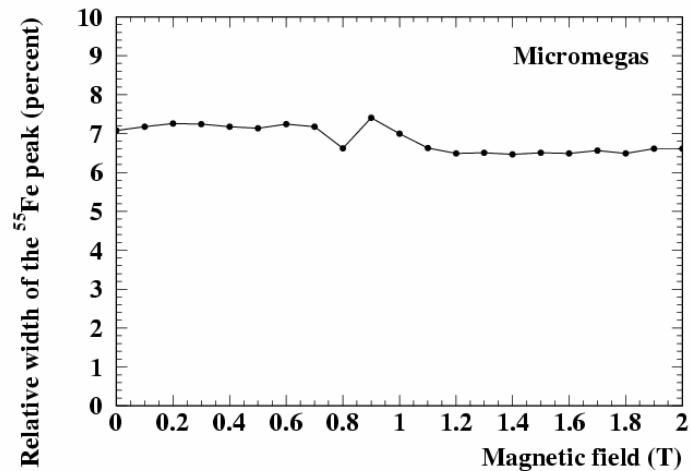
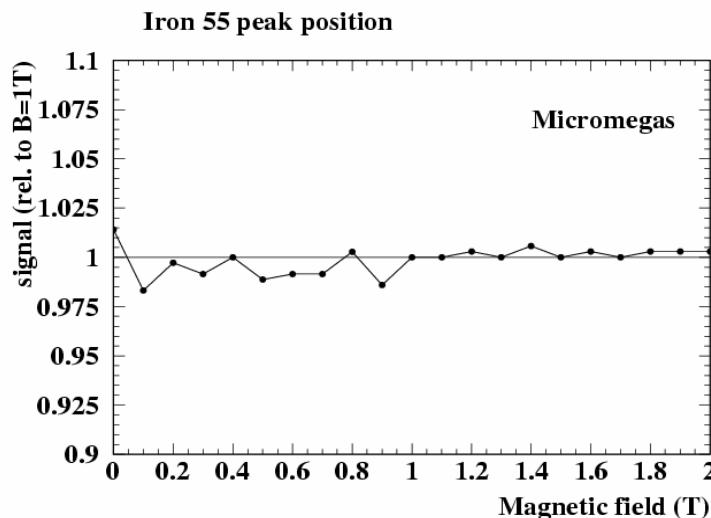


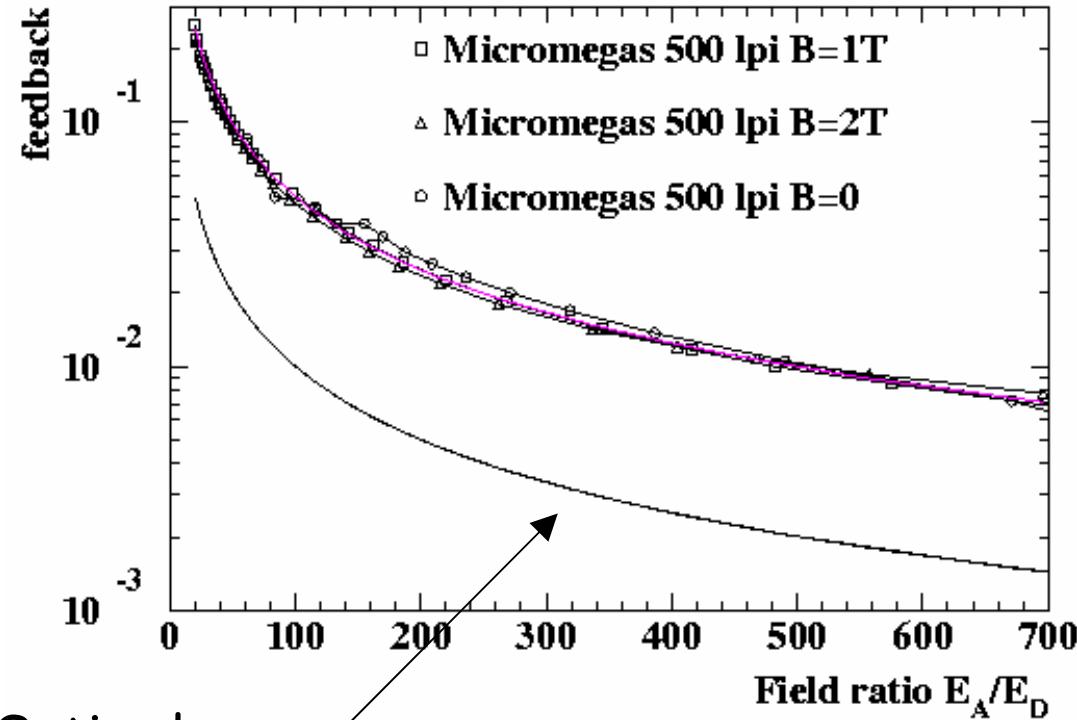
# Review of previous studies

- Monte Carlo studies allowed us to limit the choice of gas mixtures for Micromegas. Ar-CF<sub>4</sub> is one of the favorite with possibly an isobutane or CO<sub>2</sub> admixture.
- These results are supported by experimental tests (drift velocity measurements, gains, aging tests, attachment)
- Theoretical and experimental studies have demonstrated that the ion feedback can be suppressed down to the 3 per mil level.
- Tests with simple dedicated setups have proven the principle of operation and shown that the performances of Micromegas hold in a magnetic field (March 2002, June 2002 and January 2003 data taking)

# Measurements in a magnetic field with a 15 cm TPC

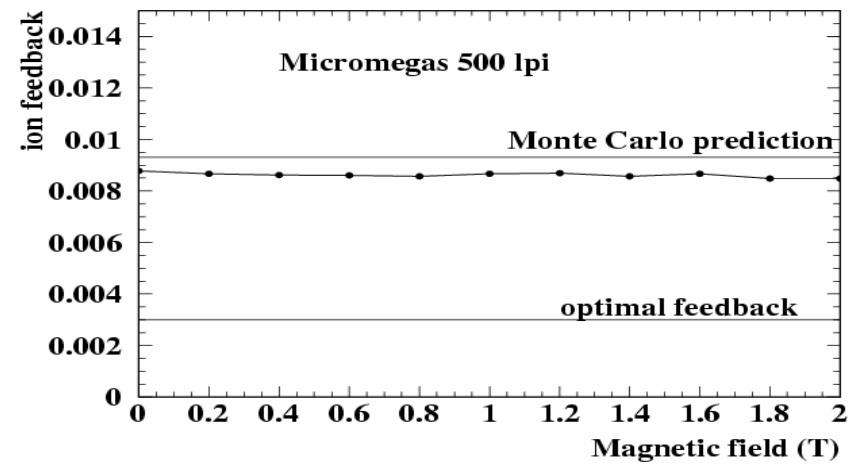
Stability of the position and width of the  $^{55}\text{Fe}$  peak as a function of the field





Optimal case

(reached for a 1000  
lpi grid)

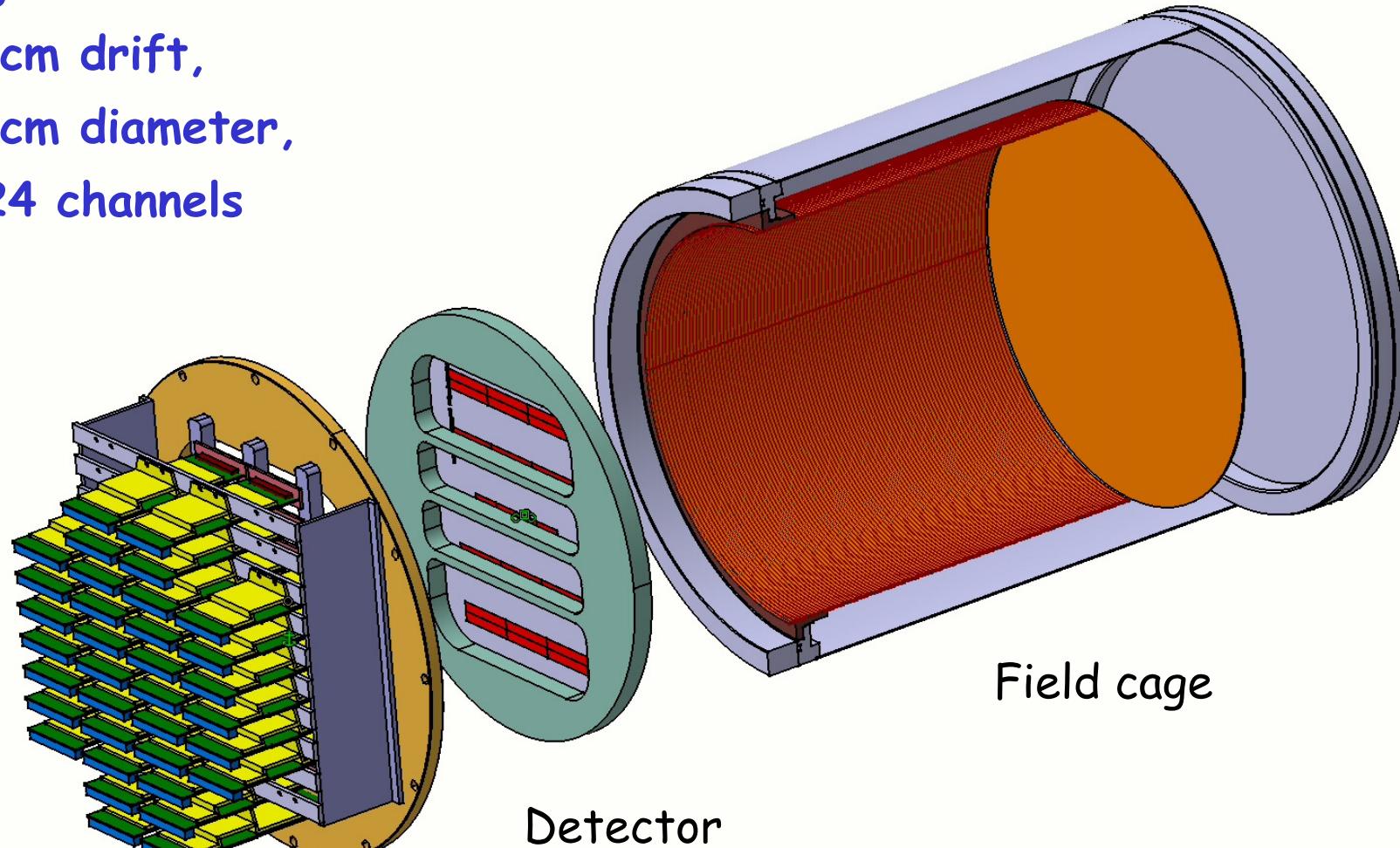


Good understanding and stability of the ion feedback : need for manufacturing large grids at the 25 micron pitch.

Next step: see tracks in a  
large-scale TPC

50 cm drift,  
53 cm diameter,  
1024 channels

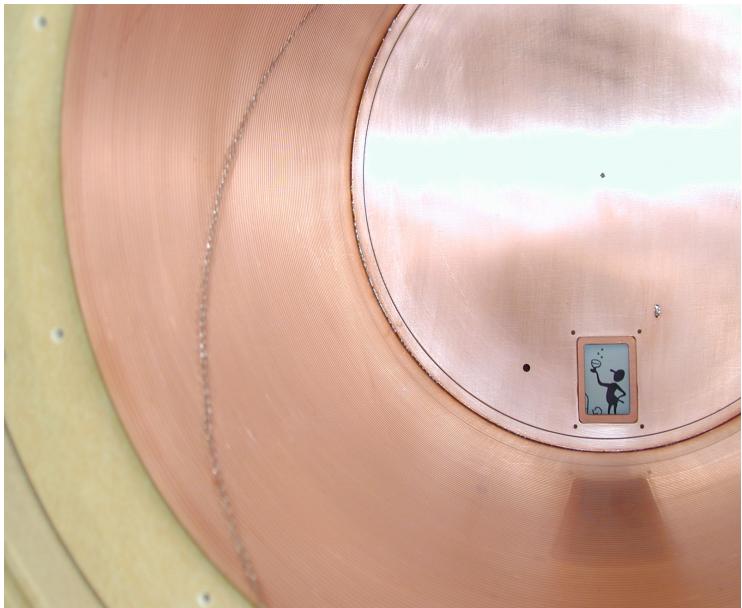
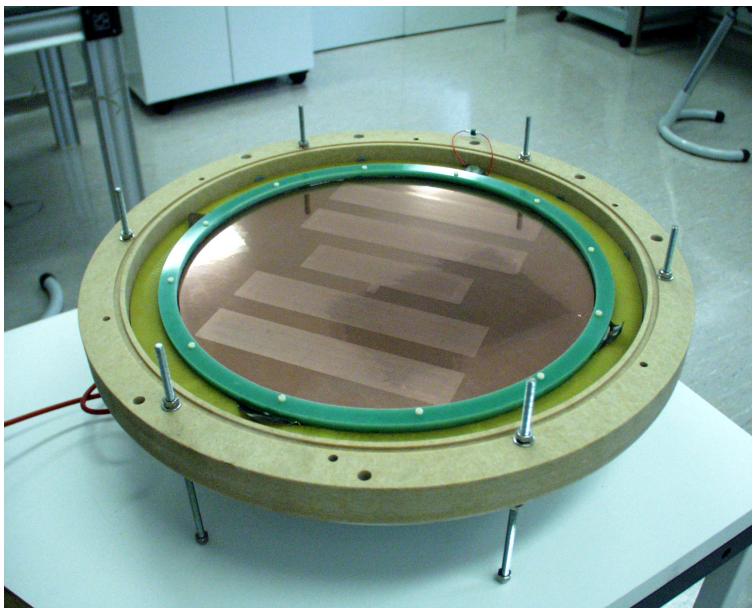
-> COSMIC RAY TEST

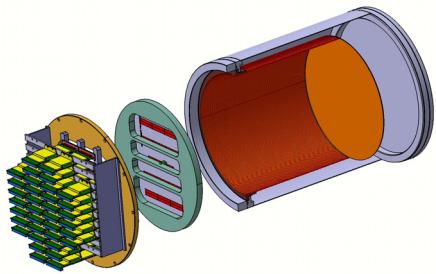


Front end electronics

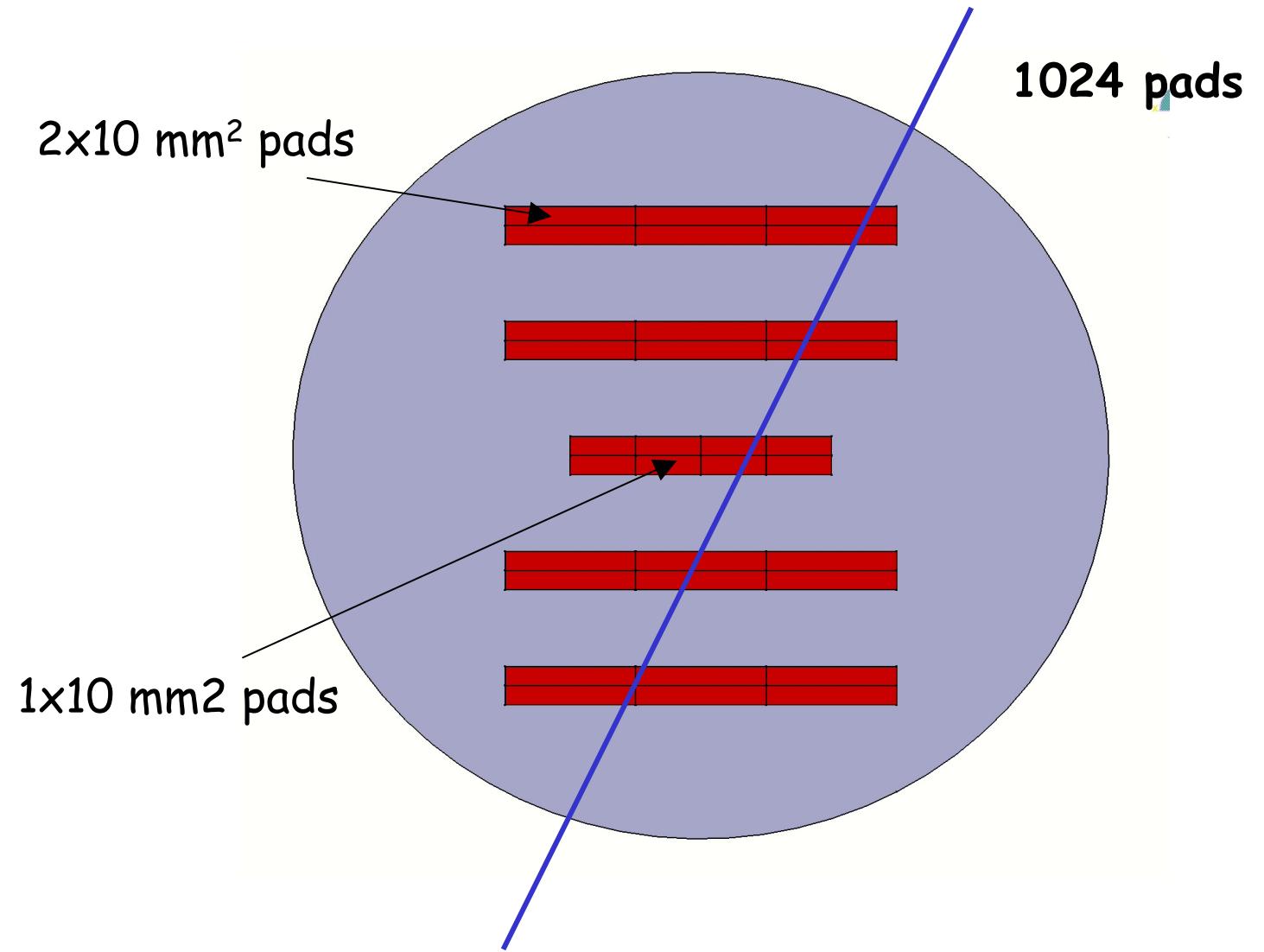
FROM CONCEPTION...

# ...TO REALITY





## Readout anode pad plane



## LC-TPC gas choices

### Gases:

Ar-CH<sub>4</sub> e.g. P10 – 90:10 %

Some concern about neutron background sensitivity.

Ar-CO<sub>2</sub>

Slow gas, requiring larger drift fields.

Tesla TDR Gas (Ar-CH<sub>4</sub>-CO<sub>2</sub>)

Lower drift field and less hydrogen.

Ar-Isobutane

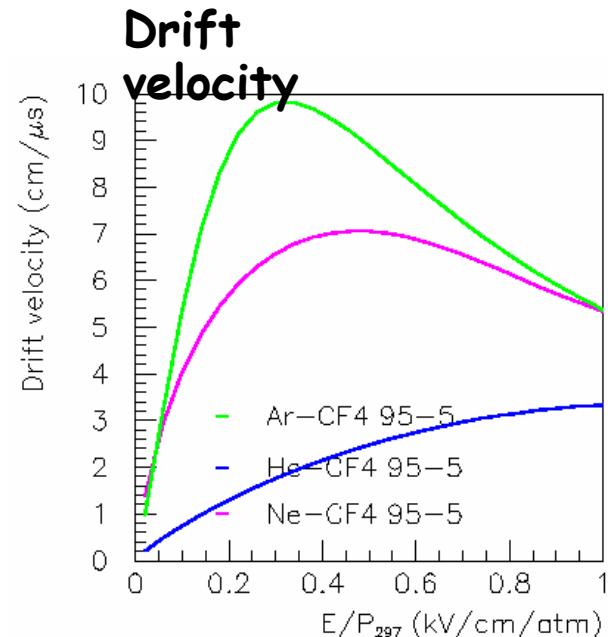
Interesting. Reasonably fast.

Ar-CF<sub>4</sub>

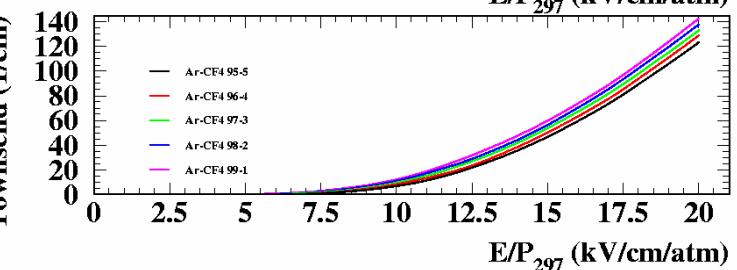
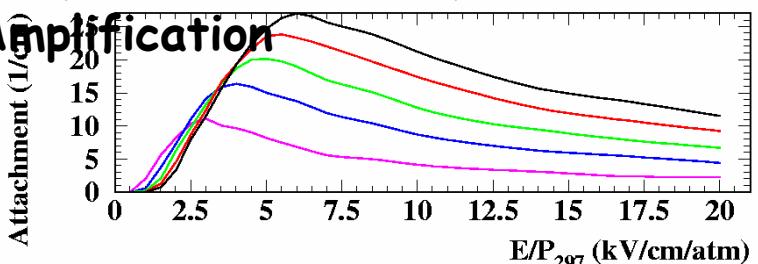
Very interesting. Very fast, no hydrogen.

$\omega\tau > 20 \rightarrow$  potential transverse diffusion

Need to worry about resonant attachment and reactions.



### ArCF<sub>4</sub> Attenuation / Amplification



First events observed during July shake down followed by data taking runs in September and October, all without a magnet field. Two week final commissioning and pilot run in November with B = 0, 0.5, 1 and 2T.

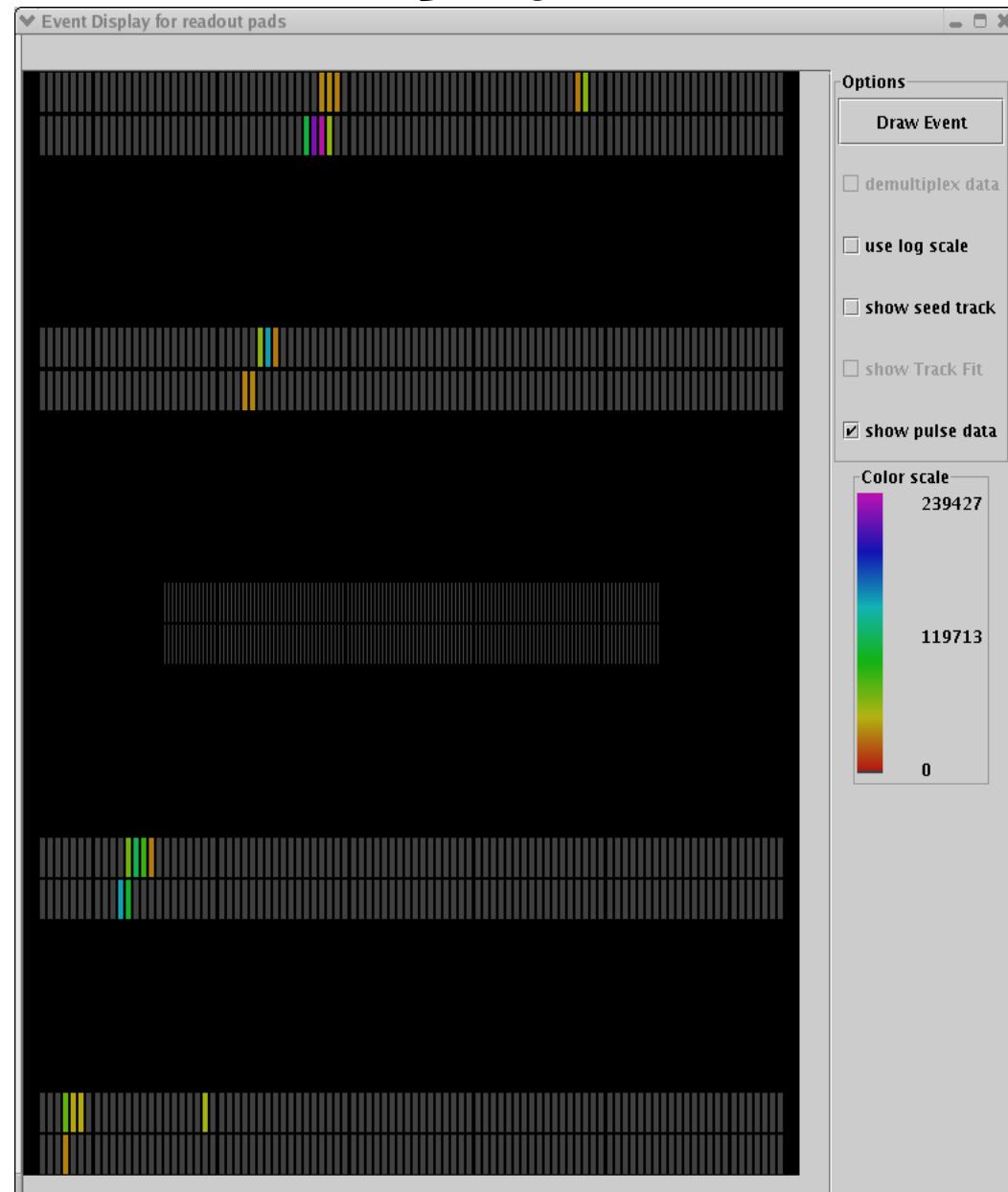
Gas:

Ar-CH<sub>4</sub> 10%

Ar-Isobutane 5%

Ar-CF<sub>4</sub> 3%

Display and reconstruction using Java code from Dean Karlen and U. Victoria group, adapted for Micromegas studies by MR.



## DAQ and analysis

STAR test DAQ, VME based.

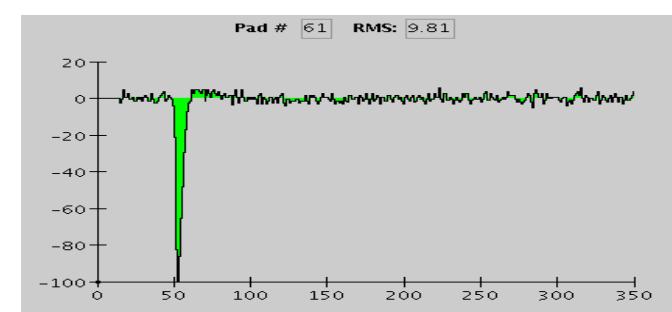
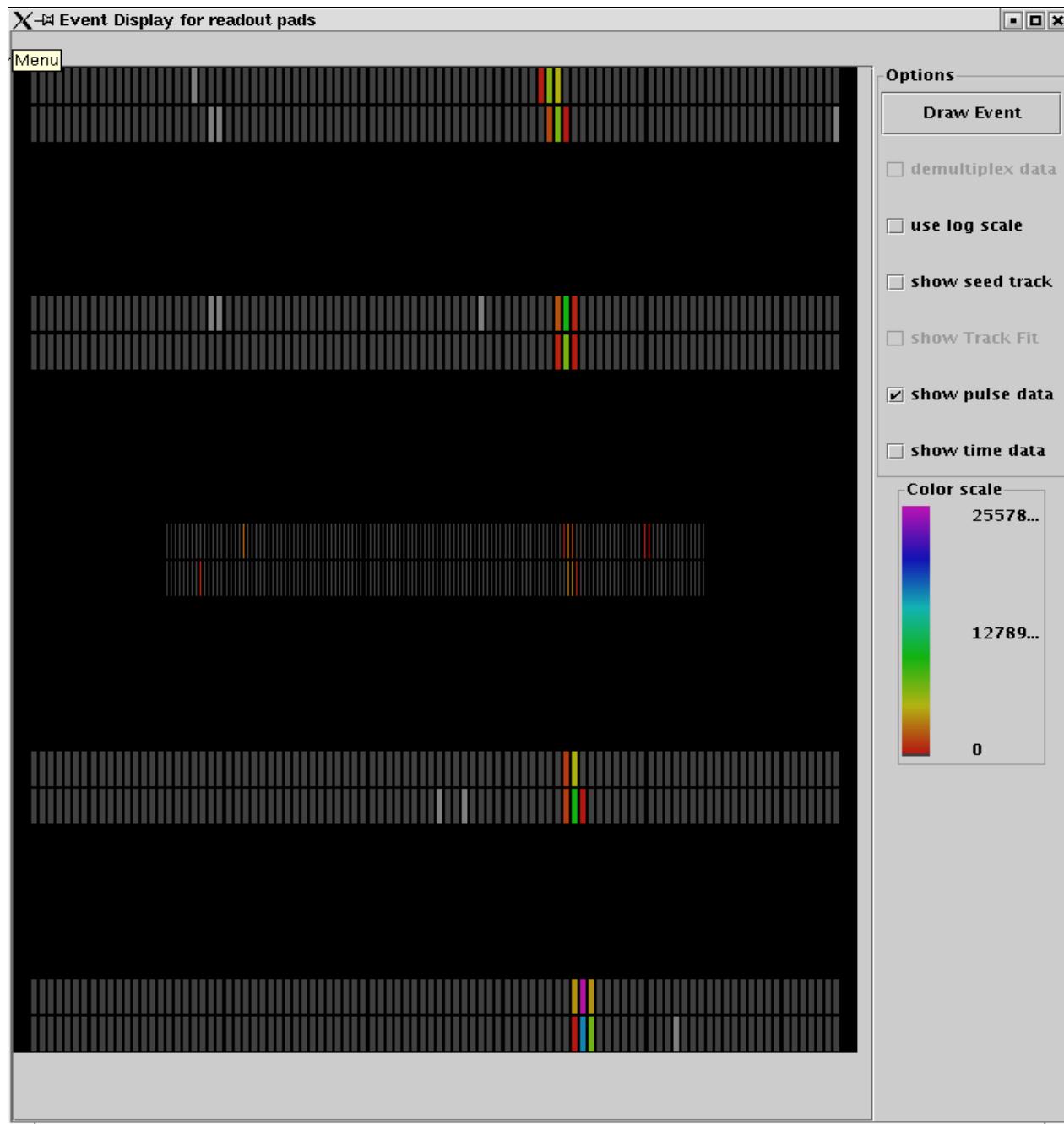
Very steady data taking conditions, with mesh currents below 0.3 nA and essentially no sparking.

Trigger rate 1-2 Hz

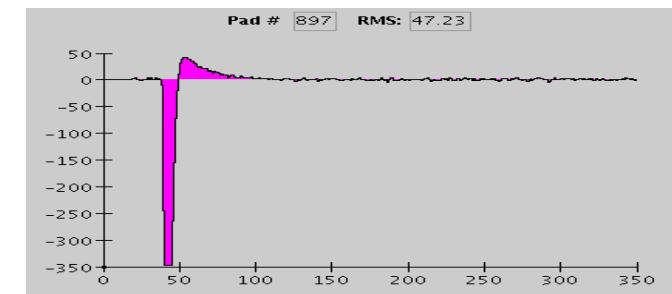
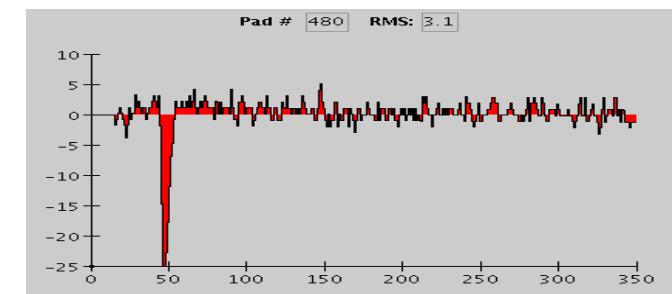
Data taking rate limited by DAQ (no zero suppression, slow connections)

Event files converted in LCIO format with zero suppression.  
This gains a factor of 1000 in disk space.

Java-based analysis (JAS3 and AIDA)



Ar-Iso 5%, Vmesh =  
300 V  
B = 1 Tesla wT ~ 2



Gas

E field

**Argon Isobutane 5%**

200 V/cm

 $v_{\text{drift}}$   
diffusion $\sim 5 \text{ cm}/\mu\text{sec}$  $\sim 400\text{-}500 \mu\text{m} @ 1 \text{ cm}$ Micromegas

Vmsh

300 V

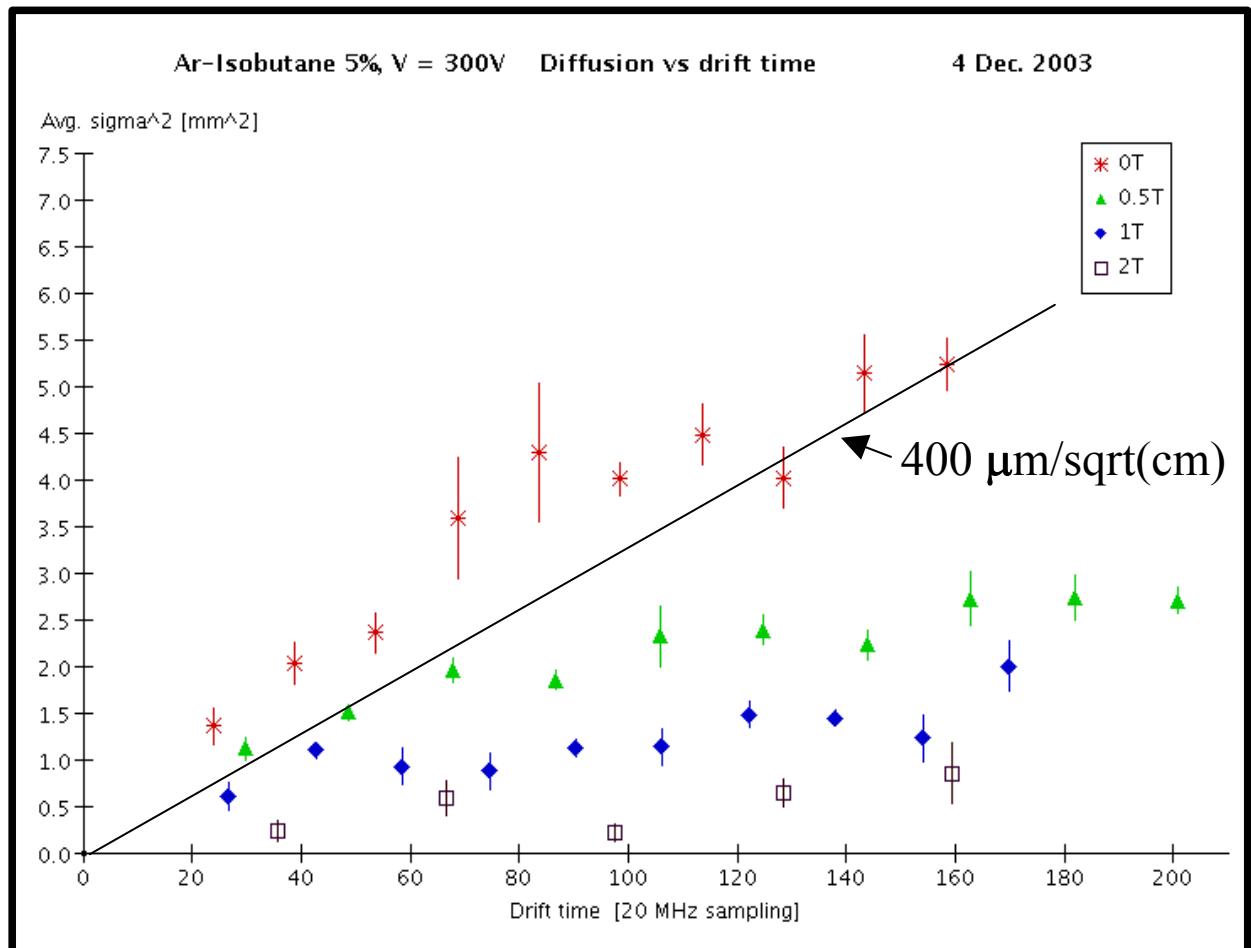
Expected transverse diffusion

$$\frac{B \text{ field}}{\mu\text{m}/\sqrt{\text{cm}}} \quad \frac{\omega \tau}{\text{cm}} \quad \text{Diff. (}$$

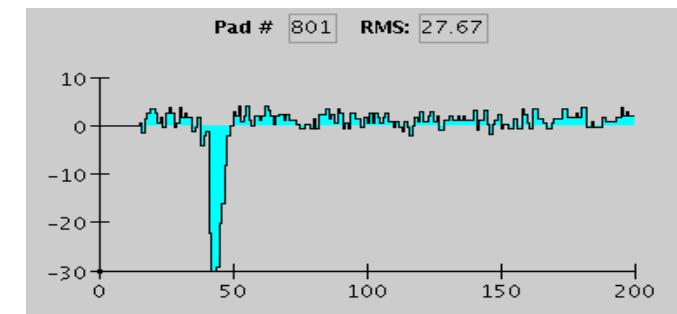
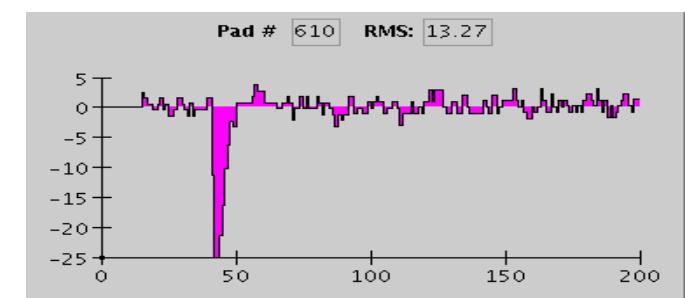
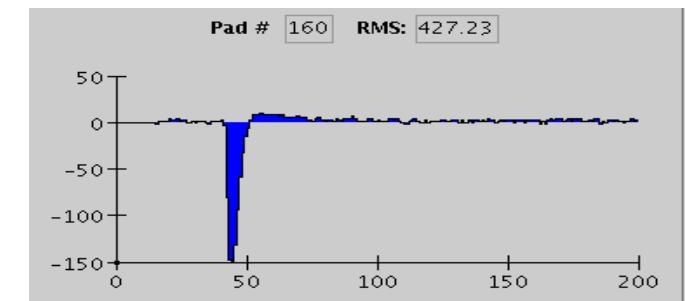
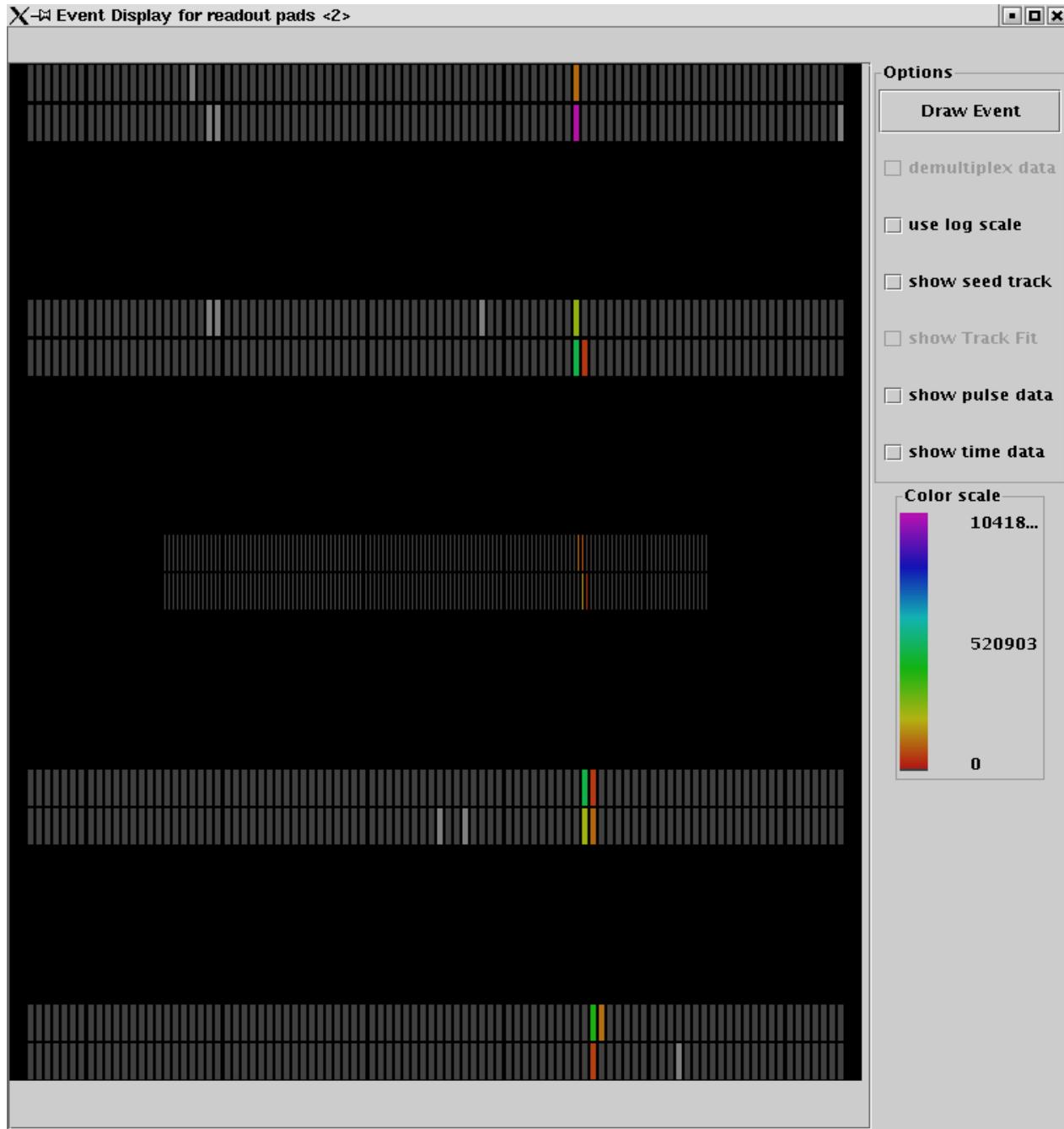
|       |      |     |
|-------|------|-----|
| 0 T   | 0    | 400 |
| 0.5 T | 1.25 | 250 |
| 1 T   | 2.5  | 150 |
| 2 T   | 5    | 80  |
| 3 T   | 7.5  | 53  |
| 4 T   | 10   | 40  |

For B = 3 T and

$$\frac{d = 50 \text{ cm}}{375} \quad \frac{1 \text{ m}}{530} \quad \frac{2.5 \text{ m}}{835 \mu\text{m}}$$



### X-Event Display for readout pads <2>



Gas

E field

**Argon CF<sub>4</sub> 3%**

200 V/cm

v<sub>drift</sub>

diffusion

10 cm/ $\mu$ sec $\sim$ 400-500  $\mu$ m @ 1 cmMicromegasV<sub>mesh</sub>

340 V

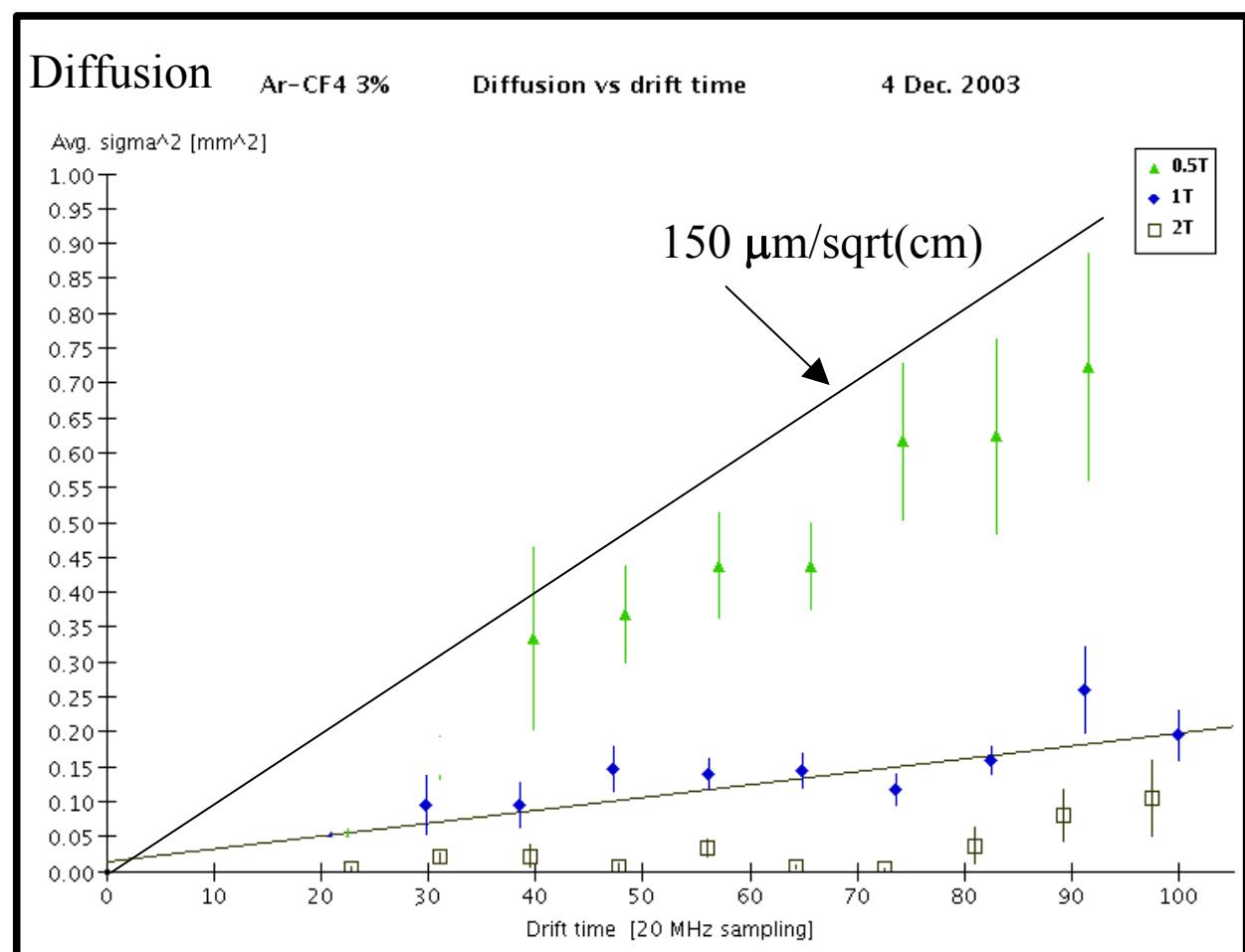
Expected transverse diffusion

$$\text{B field } \frac{\omega\tau}{\mu\text{m}/\sqrt{\text{cm}}} \text{ Diff. (}$$

|       |     |     |
|-------|-----|-----|
| 0 T   | 0   | 400 |
| 0.5 T | 2.5 | 150 |
| 1 T   | 5   | 80  |
| 2 T   | 10  | 40  |
| 3 T   | 15  | 27  |
| 4 T   | 20  | 20  |

For B = 3 T and

$$\frac{d = 50 \text{ cm}}{188} \quad \frac{1 \text{ m}}{266} \quad \frac{2.5 \text{ m}}{421 \mu\text{m}}$$



0 cm

50 cm

$\Rightarrow$  Can't measure track width at B = 2T in using Ar-CF<sub>4</sub> with present readout system.

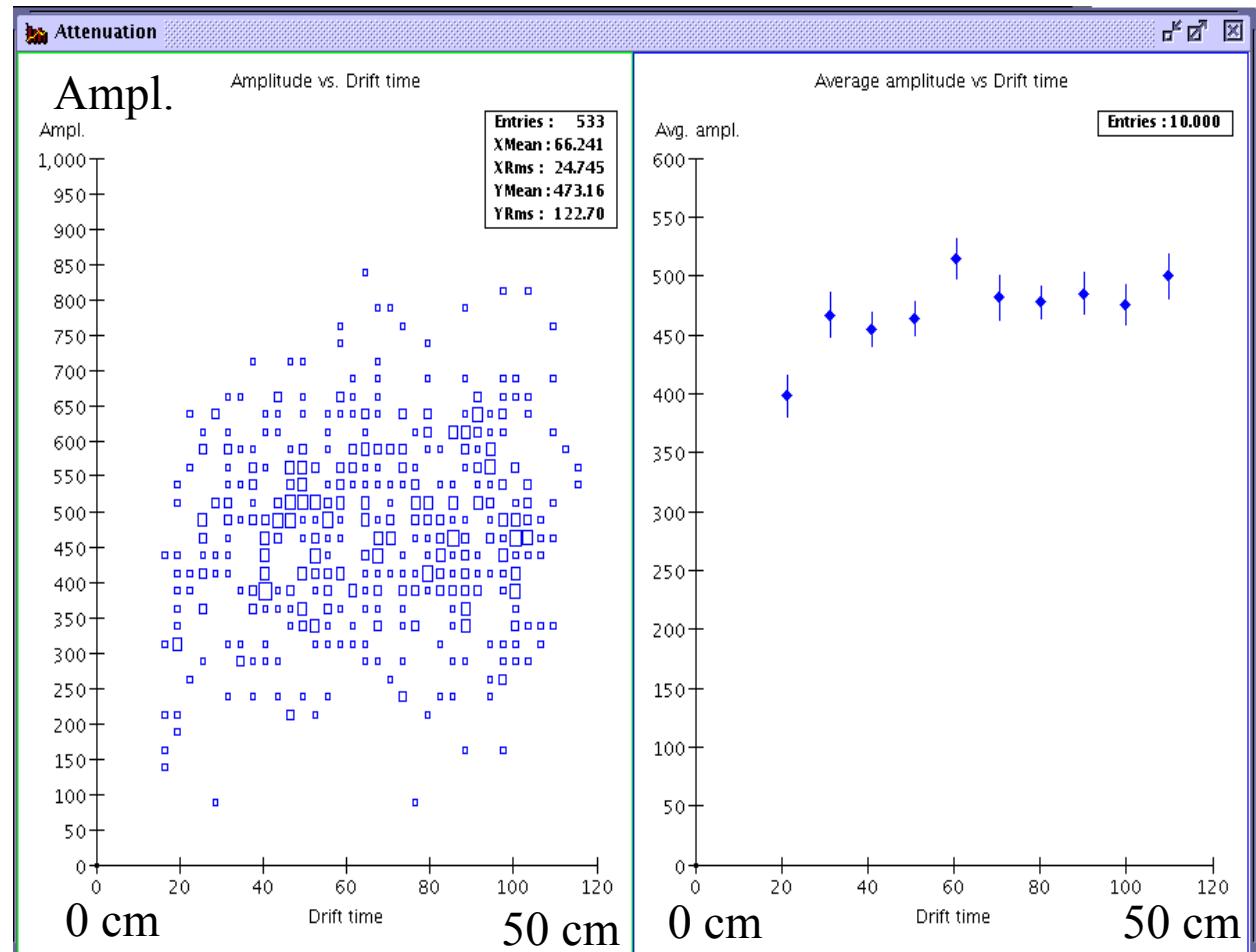
**Ar-CF4 attenuation check:**

Use 4 pad rows not included in track finding.

Calculate amplitude on each pad row, average for each track and plot vs. drift time.

Plot average track amplitude in several drift time bins.

Find no significant attenuation in low field (200V/cm) drift volume.



# Software developments

## Pedestal subtraction

Skip first 15 time buckets, calculate mean and spread for next 15 and last 15 time buckets.  
Calculate pedestal and slope.

## Data correction

Remove problem channels and subtract digital glitches.

## Track finding

Try different patterns, e.g.

9801 – Use rows 9 and 1 as seed rows  
verify with rows 8 and 0.

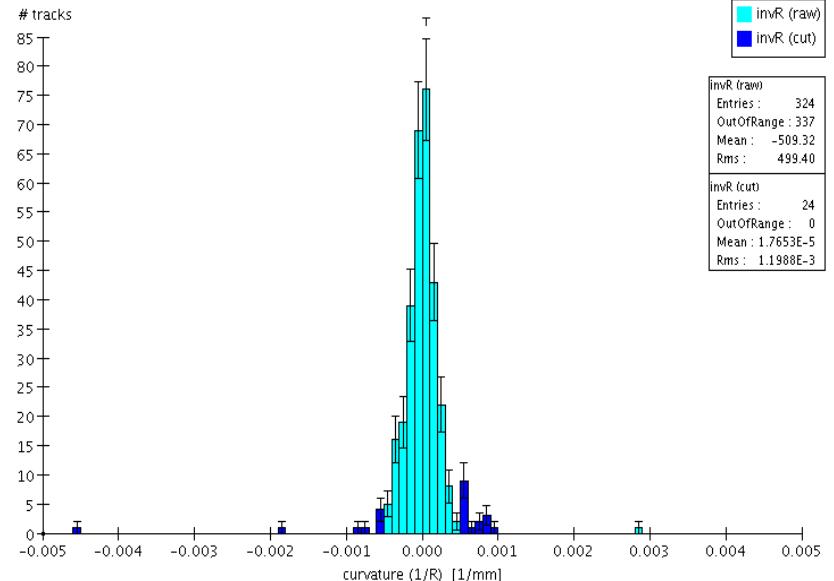
## Track fitting

Fit **x0, phi, sigma and invR**  
using pad rows 0,1, 4,5 and 8,9.

## Resolution and attenuation studies

Use pad rows 2,3 and 6,7.

Ar-CF4 3%      Track curvatures      B = 1 Tesla



Read raw data files (1 event per file – 1.2 MB), write SLCIO zero-compressed output file (X1000 reduction), read SLCIO file, perform analysis and write ntuple.

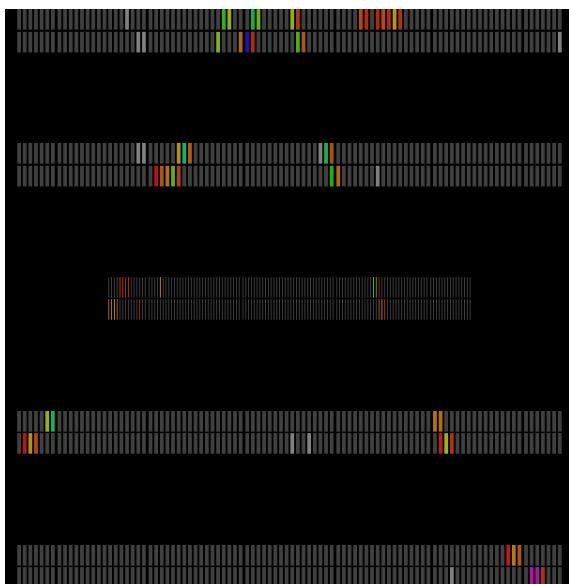
Analyze ntuple using Java code or scripts. Fill AIDA 1 and 2D histograms and plot within JAS3.

Use XV to save plots in GIF format for input to OpenOffice 1.0, or output directly as PS.

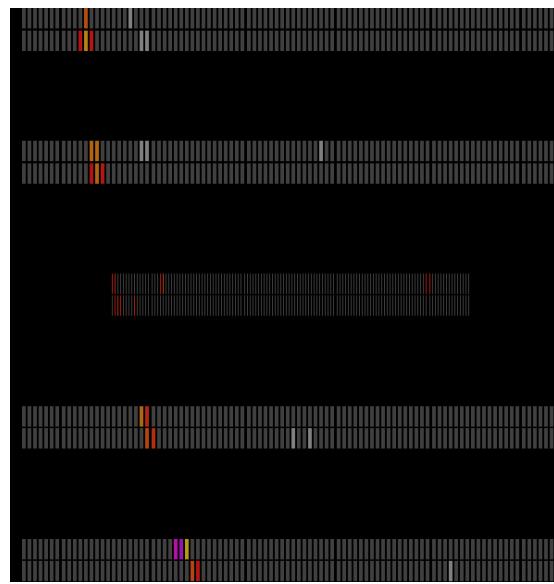
Ar-CF4 3% Curved tracks

B = 1 Tesla

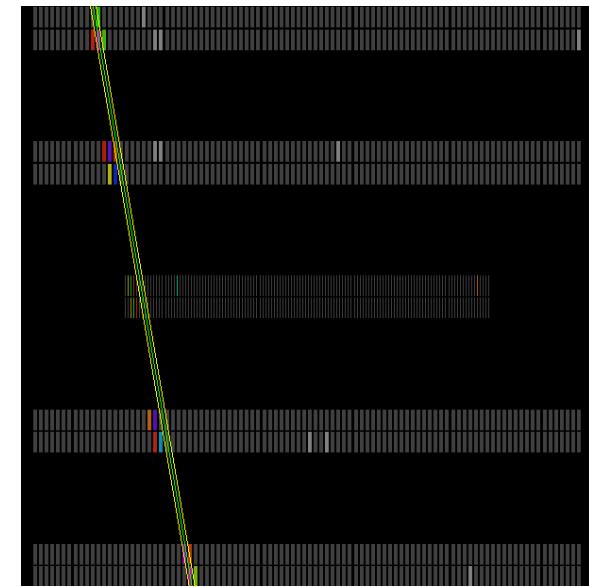
Evt #504



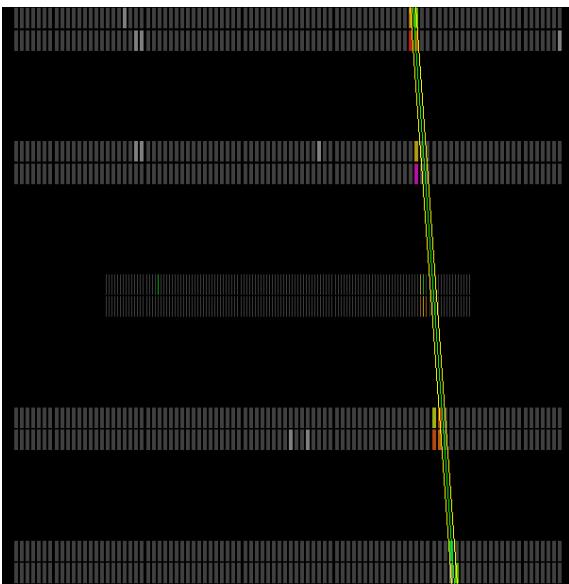
Evt #902



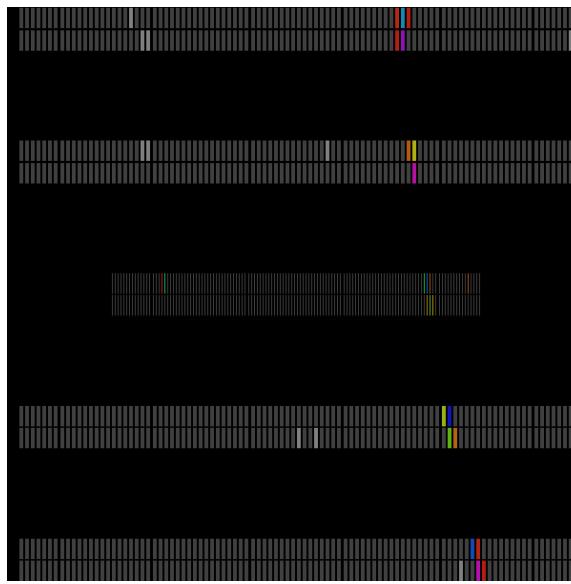
Evt #1456



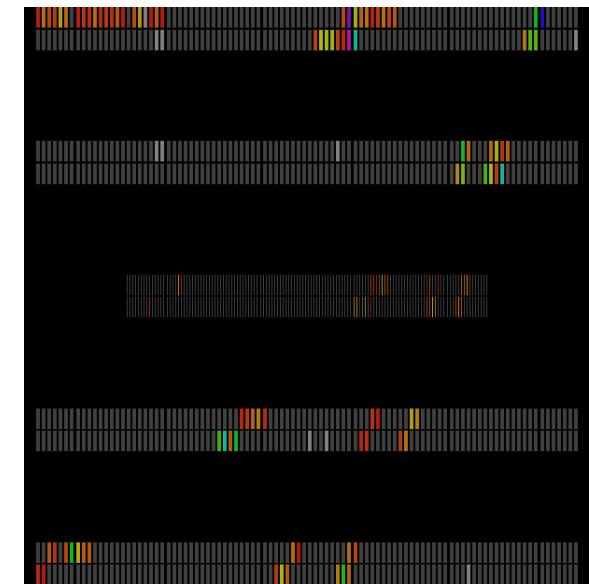
Evt #2303



Evt #2826



Evt #3608



## Plans

Analyse data:

Improve pedestal calculation and zero suppression,

Develop electronics calibration,

Study cluster finding and track fitting, and

Develop ntuple analysis.

Improve triggering and DAQ, install a new PC, ...

Take more data with magnetic field.

**Study ways to improve resolution.**

**Need to spread signal over 2-3 pads to obtain optimal resolution.**